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Mr. Hook's Answer to Monsieur Auzout's  
*Considerations, in a Letter to the Publisher  
 of these Transactions.*

SIR,

Together with my most hearty thanks for the favour you were pleased to do me, in sending me an *Epitome* of what had been by the ingenious Monsieur *Auzout* animadverted on a description, I had made of an *Engine* for grinding *spherical Glasses*, I thought my self obliged, both for your satisfaction, and my own Vindication, to return you my present thoughts upon those Objections. The chief of which seems to be against the very *Proposition* it self: For it appears, that the *Objector* is somewhat unsatisfied, that I should propound a thing in *Theory*, without having first tried the *Practicableness* of it. But first, I could wish that this worthy Person had rectified my mistakes, not by speculation, but by experiments. Next, I have this to answer, that (though I did not tell the *Reader* so much, to the end that he might have the more freedom to examine and judg of the contrivance, yet) it was not meer *Theory* I propounded, but somewhat of *History* and *matter of Fact*: For, I had made trials, as many as my leisure would permit, not without some good success; but not having time and opportunity enough to prosecute them, I thought it would not be unacceptable to such, as enjoyed both, to have a description of a way altogether *New*, and *Geometrisally* true, and seemingly, not unpracticable, whereof they might make use, or not, as they should see reason. But nothing surpris'd me so much, as, that he is pleased (after he had declared it a fault, to write this *Theory*, without having reduced it to practice) to lay it, as he seems to do, in one place of his book, *p. 22* upon the *Royal Society*. Truly, Sir, I should think my self most injurious to that *Noble Company*, had I not endeavour'd, even in the beginning of my Book, to prevent such a misconstruction. And therefore I cannot but make this interpretation of what Monsieur *Auzout* saith in this particular, that either he had not so  
 much

much of the Language wherein I have written, as to understand all what was said by me, or, that he had not read my *Dedication* to the *Royal Society*, which if he had done, he would have found, how careful I was, that that *Illustrious Society* should not be prejudiced by my *Errors*, that could be so little advantaged by my *Actions*. And indeed, for any man to look upon the matters published by their Order or Licence, as if they were *Their* Sense, and had *Their* Approbation, as *certain* and *true*, 'tis extremely wide of their intentions, seeing they, in giving way to, or encouraging such publications, aim chiefly at this, that *ingenious conceptions*, and important *philosophical matter of Fact* may be communicated to the learned and enquiring World, thereby to excite the minds of men to the examination and improvement thereof. But, to return; As to his *Objections* against the *Matter*, I do find that they are no more against mine, than any other way of *Grinding Glasses*; nor is it more than I have taken notice of my self in this Passage of the same *Paragraph*, of which sort are also those difficulties he raises about *Long Glasses*, which are commonly known to such, as are conversant in making them. *It would be convenient also* (these are my words) *and not very chargeable, to have four or five several Tools: One, &c.* And, *if curiosity shall ever proceed so farr, one for all lengths, between 1000. and 10000. foot long; for indeed, the Principle is such, that supposing the Mandrils well made, and of a good length, and supposing great care be used in working and polishing them, I see no reason, but that a Glass of 1000. nay, 10000. foot long may be made, as well as one of 10.* For, *the reason is the same, supposing the Mandrils and Tools be made sufficiently strong, so that they cannot bend; and supposing also, that the Glass out of which they are wrought, be capable of so great a regularity in its parts, as to its Refraction.* But next, I must say that his *Objections* to me, seem not so considerable, as perhaps he imagines them. For, as to the possibility of getting Plates of Glass thick and broad enough without veins, I think that not now so difficult here in *England*, where I believe is made as good, if not much better Glass for *Optical Experiments*, than ever I saw come from *Venice*. Next, though it were better, that the thickest part of a long *Object-Glass* were exactly in the middle, yet I can assure Monsieur *Auxout*, that it may be a very good

good one, when it is an Inch or two out of it. And I have a good one by me at present, of 36. foot, that will bear an *Aperture*, if *Saturn* or the *Moon* in the *twilight*, be look'd on with it, of  $3\frac{1}{4}$  Inches over, and yet the thickest part of the *Glass* is a great way out of the middle. And I must take the liberty to doubt, whether ever my *Animadversor* saw a long *Glass*, that was otherwise; as he might presently satisfy himself by a way I could shew him (if he did not know it) whereby the difference of the thickness of the sides might be found to the hundredth part of a Line.

As to the exceeding exactness of the *Figure* of Long *Object-Glasses*, 'tis not doubted, but that it is a matter difficult enough to be attained any way: but yet, I think, much easier by *Engine*, than by *Hand*; and of all *Engines*, I conceive, none more plain and simple, than that of a *Mandril*. And for making *spherical Glasses* by an *Engine*, I am apt to think, there hardly can be any way more plain, and more exact, than that which I have described; wherein there is no other motion, than that of two such *Mandrils*, which may be made of sufficient strength, length, and exactness, to perform abundantly much more, than I can believe possible to be done otherwise than by chance, by a man's hands or strength unassisted by an *Engine*, the motion and strength being much more certain and regular. I know very well, that in making a 60. foot *Glass* by the strength of the hand, in the common way, not one of ten that are wrought, will happen to be good, as I have been assured by Mr. *Reeves*; who, I am apt to think, was the first that made any good of that length. For the *Figure* of the *Tool* in that way is presently vitiated by the working of the *Glass*, and without much *gaging* will not do any thing considerable. Besides, the strength of a man's hands, applied to it for the working and polishing of it, is very unequal, and the motions made, are very irregular; but in the way, I have ventured to propose, by *Mandrils*, the longer the *Glass* and *Tool* are wrought together, the more exact they seem to be, and if all things be ordered, as they should be, the very polishing of the *Glass*, does seem most of all to rectify the *Figure*.

As to what he objects, that the *Tool* does only touch the *Glass* in a *Mathematical Circle*; that is true, perhaps, at first, but before the *Glass* is wrought down to its true *Figure*, the *Edge* of the *Tool* will

will be worn or grownd away, so as that a Ring of an inch broad may be made to touch the *Spherical Surface* of the Glas; nay, if it be necessary (without much trouble, especially in the grinding of longer Glases) the whole *Concave Surface* of the Tool may be made to touch a Glas. Besides, that as to the keeping a quantity of the same sand and Powders of several finesses, according as the glas wears, the same is possible to be don, as with the same Sand wrought finer by working in the Ordinary way.

The giving the *Inclination* to the *Mandrels*, is not at all difficult; though perhaps to determine the length exactly which the Glas so made shall draw, is not so easie: But 'tis no matter, what length the Glas be of, so it be made good, whether 60 or 80 foot, or the like. Nor is it so very difficult, to lay them both in the same *Plain*. And to keep them *steddy*, when once fix'd, is most easie.

As to the Calculation of the propriety of a Glas of a thousand foot, perhaps for that particular Length, I had not, nor have as yet calculated, that the Convexity of one of eighteen inches broad, will not be above a seventh part of a Line. But it does not thence follow, that I had not considered the difficulties, that would be in making of it. For, I must tell him, that I can make a *Plano convex* Glas, though its convexity be of a smaller sphere than is usual for such a length, to be an *Object-Glas* of about 150 foot in Length, nay of 300 foot, and either longer or shorter, *without* at all *altering the convexity*. So that, if he will by any Contrivance he hath, give me a *Plano-convex* Glas of 20, or 40 foot *Diameter*, without *Veins*, and truly wrought of that *Figure*, I will presently make a *Telescope* with it, that with a single Ey-glas shall draw a thousand foot: Which *Invention*, I shall shortly discover, there being, I think, nothing more easie and certain. And if a *Plano-convex* Glas can be made of any *Sphere* between twenty and forty foot *radius*, so as that both the *Convex* and *Plain* side of the Glas be exactly polish'd of a true *Figure*, I will shortly shew, how therewith may be made a *Telescope* of any Length, supposing the Glas free from all kind of *Veins*, or inequality of *Refraction*.

As for the sliding of the Glas upon the *Cement*, I see no reason at all for it, at least in the *Cement*, I make use of, having never observed any such accident in hard *Cement*. And

And for the Bearing of the *Ring* against one side of the *Glass* only at a time, I cannot see, why *that* should produce any inequality, since all the sides of the *Glass* have successively the same pressure.

His ratiocination concerning a *Glass* of 300 foot, is much the same with the former, about the difficulty of working a true surface of a convenient figure; which how considerable both *that* and his Conclusion thereupon (*videl. That we are not to expect Glasses of above 300 or 400 foot long at most, and that neither Matter nor Art will go so far*) is, may be judged from what I have newly told you of making any *Object-Glass* of any Length.

And for his good wishes, that those, who promise to make him see *Plants or Animals* in the *Moon* ( of which I know not any, that has done so, though perhaps there may be some, notwithstanding his Objections, that do not yet think it impossible to be done) had considered; what a Man is able to see with his bare Eye at 60 Leagues distance: I cannot but return him my wishes, that he would consider the difference between seeing a thing through the *Gross* and *Vaporous* Air neer the Earth, and through the Air over our heads: Which, if he observe the *Moon* in the *Horizon*, and neer the *Zenith* with a *Telescope*, he will experimentally find; and, having done so, he will perhaps not be so diffident in this matter.

Concerning his Advertisement to such, as publish *Theories*, I find not, that he hath made use of it in his own case. For, in his *Theory* about *Apertures* he seems to be very positive, not at all doubting to rely upon it, *vid.* that the *Apertures* must be *thus* and *thus* in *great Glasses*, because he had found them *so* or *so* in some *small* ones.

For his Proposal of amendments of some inconveniencies in this way, I return him my thanks; but as to his first I believe, that the matter may be contained as well in the *Concave* Tool, as on the *convex* *Glass*. And as to that of 2 *Poppet-heads*, I do not well understand it, if differing from mine; and the keeping of the Tool upon the *Glass* with a spring or weight, must quickly spoyl the whole; since, if either of the *Mandrils* will easily yield backwards, the *regularity* of all will be spoiled: and as to the wrigling and playing of the *Mandrill*, I do not at all apprehend it.

His

His *Theory of Apertures*, though he seems to think it very authentick, yet to me it seems not so cleer. For, the same Glass will endure greater or lesser *Apertures*, according to the lesser or greater Light of the *Object*: If it be for the looking on the *Sun* or *Venus*, or for seeing the *Diameters* of the *Fix'd Stars*, then smaller *Apertures* do better; if for the *Moon* in the *daylight*, or on *Saturn*, or *Jupiter*, or *Mars*, then the largest. Thus I have often made use of a 12 foot-Glass to look on *Saturn* with an *Aperture* of almost 3 inches, and with a single Eye-glass of 2 inches *double convex*: but, when with the same Glass I looked on the *Sun* or *Venus*, I used both a smaller *Aperture*, and shallower *Charge*. And though M. *Auxout* seems to find fault with the *English* Glass of 36 foot, that had an *Aperture* of but  $2\frac{1}{2}$  inches *French*, as also, with a 60 foot *Tube*, used but with an *Aperture* of 3 inches yet I do not find, that he hath seen Glasses of that length, that would bear greater *Apertures*, and 'tis not impossible, but his *Theory of Apertures* may fail in longer Glasses.

*Of a means to illuminate an Object in what proportion one pleaseth; and of the Distances requisite to burn Bodies by the Sun.*

One of the means used by M. *Auxout* to enlighten an *Object*, in what proportion one pleaseth, is by some great *Object-Glass*, by him called a *Planetary* one, because that by it he shews the difference of Light, which all the *Planets* receive from the *Sun*, by making use of several *Apertures*, proportionate to their distance from the *Sun*, provided that for every 9 foot draught, or thereabout, one inch of *Aperture* be given for the *Earth*. Doing this, one sees (*saieth he*) that the Light which *Mercury* receives, is far enough from being able to burn Bodies, and yet that the same Light is great enough in *Saturn* to see cleer there, seeing that (to him) it appears greater in *Saturn*, than it doth upon our *Earth*, when it is overcast with Clouds: Which (he adds) would scarce be believed, if by means of this Glass it did not sensibly appear so: Whereof he promises to discourse more fully in his